

Geographic, demographic, and socioeconomic variations in the investigation and management of coronary heart disease in Scotland

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Abstract

Objective—To determine whether age, sex, level of deprivation, and area of residence affect the likelihood of investigation and treatment of patients with coronary heart disease.

Design, patients, and interventions—Routine discharge data were used to identify patients admitted with acute myocardial infarction (AMI) between 1991 and 1993 inclusive. Record linkage provided the proportion undergoing angiography, percutaneous transluminal coronary angioplasty (PTCA), and coronary artery bypass grafting (CABG) over the following two years. Multiple logistic regression analysis was used to determine whether age, sex, deprivation, and area of residence were independently associated with progression to investigation and revascularisation.

Setting—Mainland Scotland 1991 to 1995 inclusive.

Main outcome measures—Two year incidence of angiography, PTCA, and CABG. **Results**—36 838 patients were admitted with AMI. 4831 (13%) underwent angiography, 587 (2%) PTCA, and 1825 (5%) CABG. Women were significantly less

likely to undergo angiography ($p < 0.001$) and CABG ($p < 0.001$) but more likely to undergo PTCA ($p < 0.05$). Older patients were less likely to undergo all three procedures ($p < 0.001$). Socioeconomic deprivation was associated with a reduced likelihood of both angiography and CABG ($p < 0.001$). There were significant geographic variations in all three modalities ($p < 0.001$).

Conclusion—Variations in investigation and management were demonstrated by age, sex, geography, and socioeconomic deprivation. These are unlikely to be accounted for by differences in need; differences in clinical practice are, therefore, likely.

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Keywords: geographic variations; socioeconomic deprivation; coronary revascularisation; ischaemic heart disease; epidemiology

Coronary heart disease (CHD) is the most common cause of death in Scotland in both men and women, accounting for more than a quarter of all deaths.^{1,2} However, there are wide variations in CHD mortality rates within

Table 1 Numbers and crude percentages of patients admitted with an AMI who subsequently underwent angiography, PTCA, and CABG within two years by age group, sex, deprivation category, and health board area of residence

	AMI admissions	Angiography n (%)	p value	PTCA n (%)	p value	CABG n (%)	p value
Age group*			< 0.0001		< 0.0001		< 0.0001
< 50 years	3110	1191 (38)		188 (6)		324 (10)	
50-59 years	6504	1733 (27)		205 (3)		680 (11)	
60-69 years	10519	1493 (14)		160 (2)		668 (6)	
≥ 70 years	16705	414 (3)		34 (0)		153 (1)	
Sex†			< 0.0001		< 0.001		< 0.0001
Male	21925	3645 (17)		405 (2)		1394 (6)	
Female	14913	1186 (8)		182 (1)		431 (3)	
Deprivation category (1 is least deprived)*			NS		NS		NS
1	1694	280 (17)		30 (2)		101 (6)	
2	4416	618 (14)		73 (2)		249 (6)	
3	7616	980 (13)		127 (2)		359 (5)	
4	9344	1115 (12)		147 (2)		383 (4)	
5	6099	806 (13)		100 (2)		297 (5)	
6	4597	590 (13)		63 (1)		270 (6)	
7	2740	408 (15)		42 (2)		156 (6)	
Missing	324	34		5		10	
Health board of residence†			< 0.001		< 0.001		< 0.001
Argyll & Clyde	3353	411 (12)		49 (2)		184 (6)	
Ayrshire & Arran	2784	237 (9)		30 (1)		113 (4)	
Borders	799	105 (13)		11 (1)		35 (4)	
Dumfries & Galloway	1211	103 (9)		8 (1)		50 (4)	
Fife	2294	196 (9)		32 (1)		73 (3)	
Forth Valley	1983	254 (13)		42 (2)		110 (6)	
Grampian	3175	603 (19)		42 (1)		183 (6)	
Greater Glasgow	6790	943 (14)		88 (1)		403 (6)	
Highland	1376	189 (14)		24 (2)		63 (5)	
Lanarkshire	4095	498 (12)		70 (2)		207 (5)	
Lothian	5305	845 (16)		150 (3)		222 (4)	
Tayside	3673	447 (12)		41 (1)		182 (5)	

*Significance tested by χ^2 test for trend; †significance tested by χ^2 test.

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Table 2 Age stratified sex specific percentages of AMI admissions followed within two years by angiography, PTCA, and CABG

Age groups	AMI admissions		Angiography		PTCA		CABG	
	Male (n)	Female (n)	Male n (%)	Female n (%)	Male n (%)	Female n (%)	Male n (%)	Female n (%)
< 50	2571	539	989 (39)	202 (38)	145 (6)	43 (8)	291 (11)	33 (6)
50–59	4805	1699	1340 (28)	393 (23)	142 (3)	63 (4)	538 (11)	142 (8)
60–69	6770	3749	1064 (16)	429 (11)	101 (2)	59 (2)	464 (7)	204 (5)
≥ 70	7779	8926	252 (3)	162 (2)	17 (0)	17 (0)	101 (1)	52 (1)

Scotland, with rates tending to be highest in the west of the country. These geographic variations can probably be attributed to different levels of risk factors such as smoking, diet, and deprivation.^{3 4}

Rates of revascularisation procedures are largely dependent on rates of angiography.^{5–8} Several studies have demonstrated variations in the general population rates of both angiography and revascularisation procedures by area of residence,⁹ sex,^{6–8} and level of deprivation.^{10–13} However, in interpreting these results cognisance must be taken of variations in the underlying incidence of disease. A number of these studies used CHD mortality as a proxy measure of incidence and generally failed to demonstrate any association between mortality and procedure rates. This suggests that the variations observed in practice cannot be attributed to variations in need and, therefore, raises the possibility of inequalities in care. However, in using mortality as a proxy measure of incidence, account must be taken of possible variations in coding and accuracy of diagnosis. Furthermore, mortality is a proxy of community incidence and, as such, takes no account of variations in the threshold for referral of CHD patients to hospital physicians. Therefore, it is difficult to determine the extent to which differences in procedure rates which

are not accounted for by differences in mortality can be attributed to variations in cardiology practice.

An alternative method is to examine investigation and treatment rates in those patients presenting to hospital with definite CHD. The numbers and severity of elective CHD admissions are dependent on referral thresholds and waiting times. Therefore, acute myocardial infarction (AMI) admissions provide a better proxy measure of the hospital incidence of CHD requiring invasive investigation.

This study examined angiography, percutaneous transluminal coronary angioplasty (PTCA), and coronary artery bypass grafting (CABG) rates following admission for AMI and the extent to which these varied by age, sex, socioeconomic deprivation level, and area of residence.

Methods

Discharge data are routinely collected on all patients admitted to Scottish hospitals using the Scottish morbidity record (SMR1). This collects information on age, sex, postcode, health board area of residence, disease code, and procedures undertaken. Diagnosis and procedure accuracy have been demonstrated to be 90% and 91%, respectively.¹⁴

Table 3 Multiple logistic regression analysis of the factors associated with progression to angiography, PTCA, and CABG within two years of an admission for AMI

Predictor variable	Angiography		PTCA		CABG	
	Odds ratio (95% CI)	p value	Odds ratio (95% CI)	p value	Odds ratio (95% CI)	p value
Sex						
Male*	1.00		1.00		1.00	
Female	0.73 (0.68 to 0.79)	< 0.001	1.21 (1.01 to 1.46)	< 0.05	0.68 (0.61 to 0.77)	< 0.001
Age (years)						
< 50*	1.00		1.00		1.00	
50 to 59	0.60 (0.56 to 0.66)	< 0.001	0.51 (0.41 to 0.62)	< 0.001	1.03 (0.90 to 1.19)	NS
60 to 69	0.27 (0.25 to 0.30)	< 0.001	0.23 (0.19 to 0.29)	< 0.001	0.62 (0.54 to 0.71)	< 0.001
≥ 70	0.04 (0.04 to 0.05)	< 0.001	0.29 (0.02 to 0.04)	< 0.001	0.09 (0.07 to 0.11)	< 0.001
Deprivation category (1 is least deprived)						
1*	1.00		1.00		1.00	
2	0.89 (0.75 to 1.06)	NS	1.00 (0.65 to 1.56)	NS	1.04 (0.82 to 1.34)	NS
3	0.84 (0.71 to 0.99)	< 0.05	0.95 (0.62 to 1.44)	NS	0.85 (0.67 to 1.08)	NS
4	0.70 (0.60 to 0.83)	< 0.001	0.77 (0.51 to 1.16)	NS	0.70 (0.55 to 0.89)	< 0.01
5	0.77 (0.65 to 0.91)	< 0.01	0.76 (0.50 to 1.17)	NS	0.80 (0.62 to 1.01)	NS
6	0.75 (0.63 to 0.89)	< 0.01	0.73 (0.47 to 1.16)	NS	0.87 (0.68 to 1.12)	NS
7	0.70 (0.58 to 0.85)	< 0.05	0.70 (0.43 to 1.16)	NS	0.70 (0.53 to 0.92)	< 0.01
Health board of residence						
Argyll & Clyde*	1.00		1.00		1.00	
Ayrshire & Arran	0.66 (0.55 to 0.78)	< 0.001	0.77 (0.46 to 1.22)	NS	0.73 (0.57 to 0.94)	< 0.05
Borders	1.38 (1.07 to 1.77)	< 0.05	1.10 (0.56 to 2.16)	NS	0.92 (0.62 to 1.34)	NS
Dumfries & Galloway	0.70 (0.55 to 0.89)	< 0.01	0.48 (0.22 to 1.02)	NS	0.78 (0.56 to 1.08)	NS
Fife	0.67 (0.55 to 0.81)	< 0.001	0.98 (0.62 to 1.55)	NS	0.59 (0.45 to 0.79)	< 0.001
Forth Valley	1.07 (0.90 to 1.29)	NS	1.45 (0.95 to 2.22)	NS	1.05 (0.82 to 1.35)	NS
Grampian	2.01 (1.73 to 2.34)	< 0.001	0.94 (0.61 to 1.45)	NS	1.10 (0.89 to 1.38)	NS
Greater Glasgow	1.24 (1.08 to 1.42)	< 0.01	0.95 (0.65 to 1.38)	NS	1.15 (0.95 to 1.40)	NS
Highlands	1.17 (0.96 to 1.43)	NS	1.15 (0.69 to 1.91)	NS	0.86 (0.64 to 1.17)	NS
Lanarkshire	0.89 (0.77 to 1.03)	NS	1.09 (0.75 to 1.58)	NS	0.85 (0.69 to 1.05)	NS
Lothian	1.55 (1.35 to 1.78)	< 0.001	2.12 (1.51 to 2.96)	< 0.001	0.82 (0.66 to 1.01)	NS
Tayside	1.16 (0.99 to 1.35)	NS	0.87 (0.57 to 1.32)	NS	0.99 (0.79 to 1.22)	NS

*Reference categories.

The data collected by individual hospitals are collated by the Information and Statistics Division (ISD) of the Scottish Health Service. Record linkage permits all SMR1 records relating to one patient to be identified, thereby allowing information to be obtained on subsequent admissions and procedures following discharge.¹⁵

Postcode of residence can be used to attribute a Carstairs deprivation category to the 5000 or so people resident within that postcode area.¹⁶ The categories are derived from 1991 census data on the proportion of residents who are unemployed, live in overcrowded accommodation, do not have access to a car, or belong to a low occupational social class. There are seven categories with category 1 representing the least deprived section of the population and category 7 the most deprived. Application of the scores to patients can demonstrate socioeconomic bias in the selection of patients for admission or procedures.

Scotland is divided into 15 health board areas. However, the three island boards are very sparsely populated and, therefore, very small numbers of procedures are undertaken on their residents. Hence this study was restricted to the 12 mainland boards.

The linked SMR1 dataset was used to identify Scottish residents who were admitted to hospital for AMI (ninth revision of the International Classification of Diseases (ICD9) 410) between 1991 and 1993 inclusive. The AMI admissions were broken down in terms of age, sex, deprivation category, and health board area of residence. The numbers of these patients who were readmitted for angiography (OPCS4 K63, K65), PTCA (OPCS4 K49), and CABG (OPCS4 K40–K48) within two years of this admission was also obtained. Two years was used to accommodate the waiting times in existence at that time.

The association between age, sex, deprivation category, and health board area of residence and the percentage of AMI patients who progressed to angiography or revascularisation was determined univariately using χ^2 tests and χ^2 tests for trend. The extent to which these associations were independent of each other was then tested using multivariate logistic regression analysis.

Results

Over the three year period 36 838 patients were admitted to hospital with a diagnosis of AMI. Of these, 21 925 (60%) were male and 14 913 (40%) were female. Their median age was 68 years and 20% belonged to the lowest two deprivation categories. Overall, 4831 (13%) underwent angiography within two years, 587 (2%) underwent PTCA, and 1825 (5%) CABG.

On univariate analysis, there were significant trends across the age groups for the use of both angiography and revascularisation procedures (χ^2 for trend, $p < 0.0001$), with older patients undergoing lower rates of all interventions (table 1). Similarly, women had significantly lower rates of all three modalities (χ^2 , $p < 0.0001$) (table 1). However, age and sex

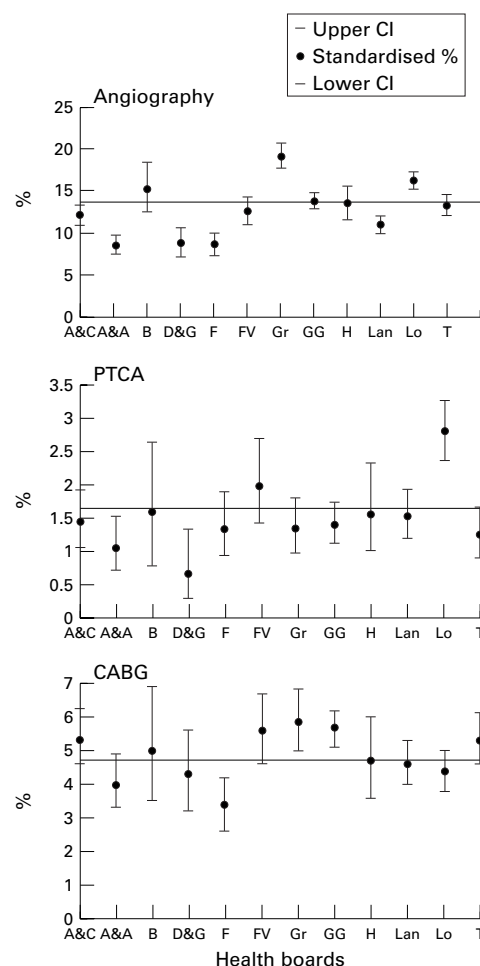


Figure 1 Age, sex, and deprivation category standardised percentages of admissions for AMI which were followed by angiography, PTCA, or CABG within two years by health board area of residence. For names of health boards see table 1.

themselves were related, with women tending to be admitted at an older age than men. Stratification by age produced more comparable rates between the sexes (table 2). There were no significant univariate associations between deprivation category and any of the procedures (table 1).

Variations were demonstrated between health board area of residence (table 1). There was a twofold variation in the crude percentages of AMI patients progressing to angiography and CABG ($p < 0.001$), and a threefold difference in those undergoing PTCA ($p < 0.001$).

On multiple logistic regression analysis women were significantly less likely to undergo angiography ($p < 0.001$) and CABG ($p < 0.001$) but more likely to undergo PTCA ($p < 0.05$) (table 3). Older patients were less likely to undergo all three interventions ($p < 0.001$). Unlike on univariate analysis, socioeconomic deprivation was associated with a reduced likelihood of both angiography and CABG ($p < 0.001$) but not PTCA. There were significant geographical variations in all three modalities ($p < 0.001$) (fig 1).

Discussion

Variations in crude population procedure rates can be difficult to interpret since they may be justified if associated with variations in incidence, risk, or benefit. The incidence of CHD is known to vary by age, sex, area of residence, and deprivation level. Therefore, comparisons within these categories must take account of incidence.

A number of studies have attempted to overcome this problem by using CHD mortality rates as a proxy measure of incidence, and comparing variations in procedure rates with variations in mortality rates. However, CHD mortality rates include patients dying outside hospital for whom coding of the cause of death is likely to be less accurate. Furthermore, mortality is a proxy measure of the community incidence of CHD rather than the hospital incidence. The latter is dependent not only on community incidence but also referral patterns, and it would be inappropriate to hold hospital physicians accountable for the management of those patients who are not known to them.

Therefore, new patients referred to hospital with definite CHD may be a more appropriate denominator for comparing hospital practice. In this study, this was further refined to AMI admissions because of the lack of consistency in applying other CHD codes, and the fact that elective admissions reflect referral thresholds and waiting times as much as they do incidence. A minority of AMI patients have normal coronary arteries but such patients would also be included if a clinical history of angina or a positive exercise test were used to identify CHD patients.

The results of this study provide evidence that the variations in provision of cardiac investigations and treatments across Scotland cannot be fully explained by variations in need. Compared with other countries, primary PTCA is a relatively uncommon procedure in all Scottish hospitals. Therefore the variations observed relate primarily to the management of patients with chronic stable angina and unstable angina.

Older CHD patients were demonstrated to be significantly less likely to be both investigated and treated after adjustment for sex, socioeconomic status, and area of residence. This supports the findings of previous studies.¹⁷ This may reflect a belief that revascularisation procedures pose a greater risk in these patients or that their benefit is reduced. A number of studies have demonstrated higher early mortality rates following revascularisation,¹⁸⁻²⁰ although these findings are not unanimous.²¹ Older patients can nonetheless gain significant symptomatic benefit from revascularisation.¹⁸⁻²²

On univariate analysis women were significantly less likely to be investigated than men. However, there was a clear association between sex and age with the peak number of women admitted for AMI occurring 10 years after that in men, and age stratified procedure rates were relatively comparable between the sexes. Nonetheless, adjustment for age, deprivation, and

area of residence in the multivariate analysis revealed a significant independent association between sex and access to angiography and CABG. Other studies have similarly demonstrated lower rates of angiography and revascularisation in women,⁶⁻⁹ even at comparable levels of morbidity.²³ Lower CABG rates in women with CHD may be justified by their lower rate of severe stenoses,⁸ the fact that they have relatively low rates of CHD mortality compared with angina,²⁴ and their higher use of PTCA. However, lower angiography rates are more difficult to explain in light of women tending to have more severe symptoms and greater functional disability than men.⁶

As with other studies,^{10-13, 25} socioeconomic deprivation was demonstrated to be associated with reduced access to angiography and CABG. The lack of a significant association with PTCA is likely to reflect the smaller numbers of patients undergoing this procedure, since the odds ratios nonetheless showed a clear trend across deprivation categories.

Significant geographical variations were demonstrated for all three modalities. Previous studies have also demonstrated geographical variations which cannot be explained by need.^{9-11, 26} These differences can, in part, be attributed to ease of access, with patients resident close to facilities most likely to be referred to them.⁹⁻¹¹

Because PTCA and CABG are both preceded by angiography, variations in angiography tend to perpetuate as variations in revascularisation.⁵⁻⁸ Therefore, access to angiography needs to be addressed before variations in revascularisation can be reduced.

Variations in practice can reflect both unnecessary interventions and unmet need. Studies from England and the USA have suggested that 25-50% of angiograms may be inappropriate.^{27, 28} However, the much higher prevalence of CHD in Scotland means that a comparable level of over provision is unlikely to be the case. In light of Scotland having one of the highest rates of CHD deaths in the world,^{29, 30} it is likely that much of the demonstrated variation in practice reflects unmet need in some areas.

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